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INTEGRATING CLIMATE AND ECOSYSTEMS SCIENCE TO INFORM MARINE ECOSYSTEM MANAGEMENT

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Abstract: Climate change has consistently been identified as a top threat to sensitive marine ecosystems such as coral reefs. However, such assessments are made largely by reference to coarse-scale global climate models and limited empirical research from single disciplines. This poster describes a NOAA-wide effort to bring together climatologists, ecologists, oceanographers, and ecosystem managers to identify critical climate-ecosystem connections, and to develop a suite of integrated information products that will improve an ecosystem manager's ability to identify potential climate impacts and variability at scales relevant to the ecosystems they manage. This Integrated Marine Protected Area Climate Tools (IMPACT) project references historical climatologies against ecological impacts to provide more relevant, quantified information to ecosystem stewards seeking to understand and plan for future environmental stresses.

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IMPACT PDF Fact Sheet (0.5 MB)

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Introduction

Over the past several years, NOAA's National Climatic Data Center (NCDC) has endeavored to open dialog between itself and several socio-economic and environmental "sectors" that have indicated a clear need for improved and focused access to climate data and information.

The work described here is based on efforts by NCDC's Marine and Coastal Ecosystems engagement team, colleagues from across NOAA, and academic partners to develop a framework for the integration, analysis, and communication of climatological, oceanographic, and ecological data; to foster the development of such integrated information products; and to refine those products based on manager feedback.

The project is called IMPACT (Integrated Marine Protected Area Climate Tools) and is intended to provide this integrated information to MPA managers and stakeholders who want to have a better understanding of how changes and variations in the overlying climate are influencing the marine ecosystems under their stewardship.

The Problem

Question: Does a knowledge that the 1°x1° grid surrounding a 100 sq. km MPA may have an annual average SST of 32°C in 2040 hold any significance with respect to ecological change?

MPA managers want to know how the climate is changing because there is a general understanding that climate change is forcing negative changes in their ecosystems and they need to address what can be done to adapt their management strategies to meet such challenges. However, there is both insufficient information relating specific climate changes to specific responses in specific ecosystems, as well as a general lack of climate literacy among managers to obtain appropriate climate information and correctly interpret it in the context of ecosystem responses.

Generalized statements such as "global warming causes coral bleaching" are an oversimplification of rather more complex issues and tend to obscure much of the physical basis behind the impact. But, for lack of understanding the nuances of the more complex interactions, such generalizations are used, resulting in often suboptimal decisions.

Climate Smart Sanctuaries

NOAA's National Marine Sanctuaries System recognized that climate change has the potential to substantially alter the health and sustainability of the ecosystems in their charge. The Climate Smart Sanctuaries Initiative was implemented "… as a way to prepare the climate site scenario/story, and then organize and implement a climate action plan at each site …"[7]

The idea is to establish a suite of actions that could be undertaken to either improve the ecosystem's resilience to climate changes, or to mitigate the stress on those ecosystems from a changing climate.

A significant limitation to any such activity was a lack of understanding of exactly how specific ecosystems or their more vulnerable components might respond to changes in the overlying climate. This understanding is twofold—first, how have they responded to historical changes, and second, how are conditions at the ecosystem scale likely to change in the future. IMPACT was initiated to address these issues.

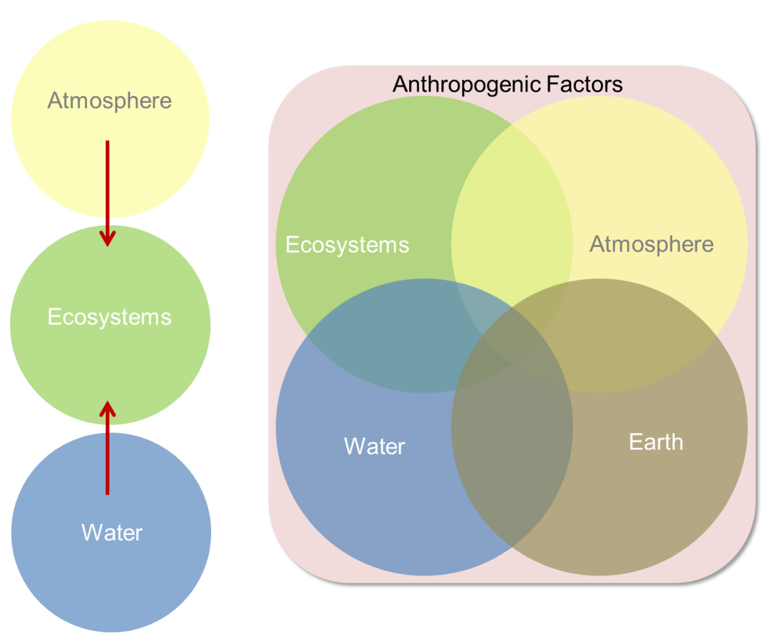
7. Office of National Marine Sanctuaries, 2010: Climate-Smart Sanctuary Initiative, Background Information. On-line at: olympiccoast.noaa.gov/AboutUs/sac/092010_climatesmart.pdf.

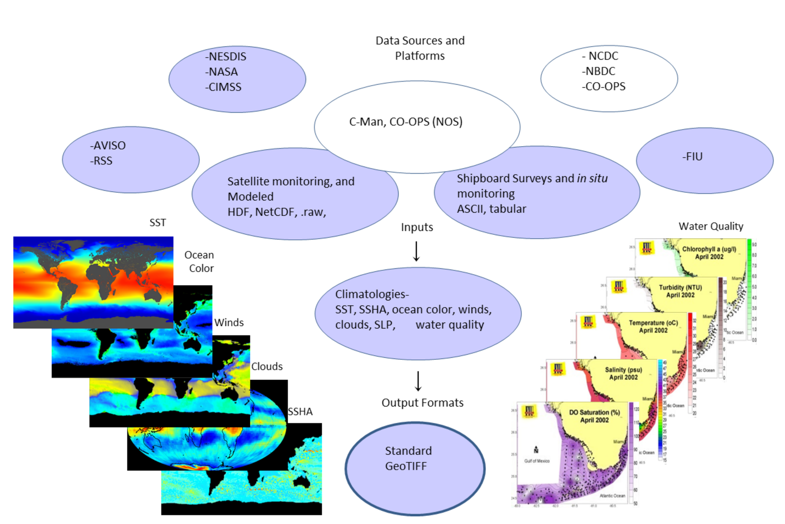
IMPACT—What is it?

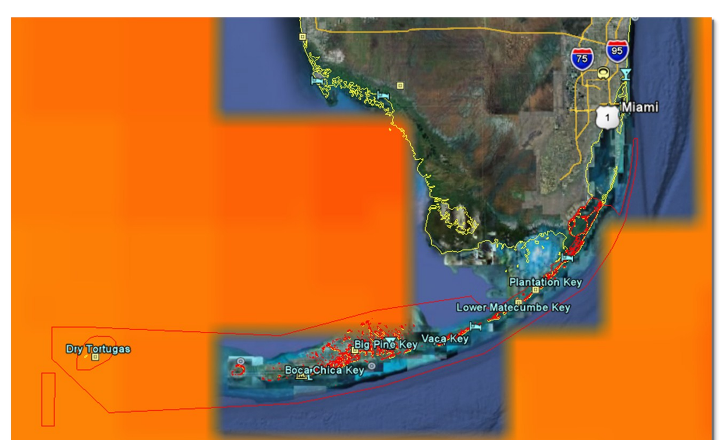
IMPACT takes a three-tiered approach to integrated climate-ecosystem assessment.

1. **Develop historical, integrated climatologies …**
   - Understand exactly how the climate over the MPA has changed to date
   - Move beyond over-simplified explanations of climate change
   - Link and quantify ecosystem reactions to relevant changes in climate
   - Resolve climate variability and change at scales important to respective ecosystems
2. **Apply learned connections to future climate scenarios …**
   - Downscale long-term projections to capture relevant spatial behavior
   - Inform ecological models
   - Add ecosystem climate impacts to short-term weather forecasts
3. **Improve climate literacy among ecosystem managers and stakeholders …**
   - Create a dialog between climate scientists and ecosystem managers
     - Facilitate improved understanding of climate information
     - Learning on both sides as to what is needed, what works, what is important, …
   - Defensible climate-oriented decision making
   - Buy-in at all levels of management

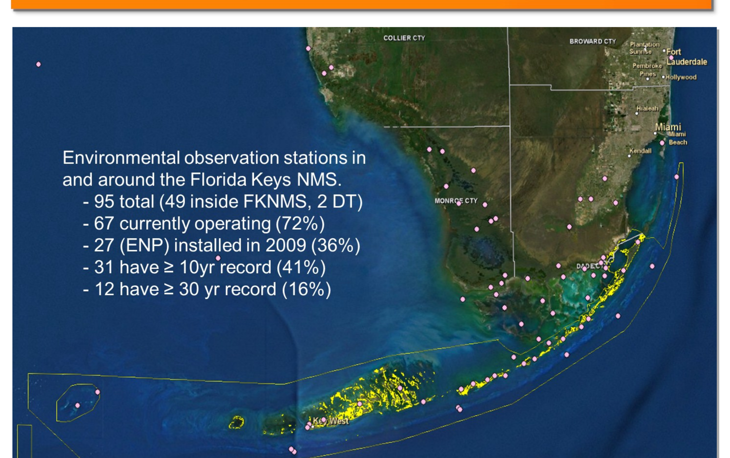
DATA ISSUES AND INTEGRATION



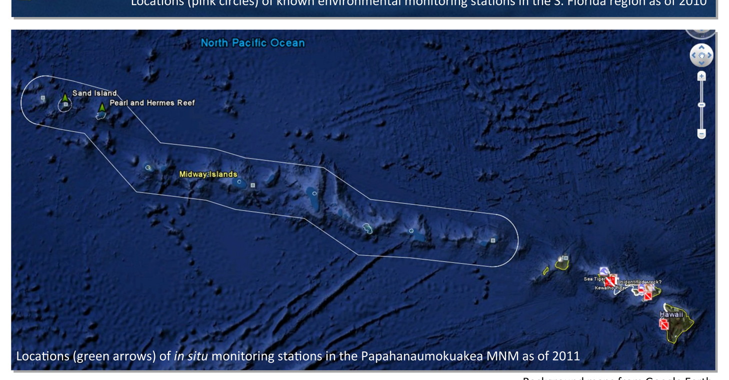




50-km August 2005 average SST over the FKNMS (NOAA CRW). Darker orange is 31-32°C, lighter is 30-31°C



Locations (pink circles) of known environmental monitoring stations in the S. Florida region as of 2010



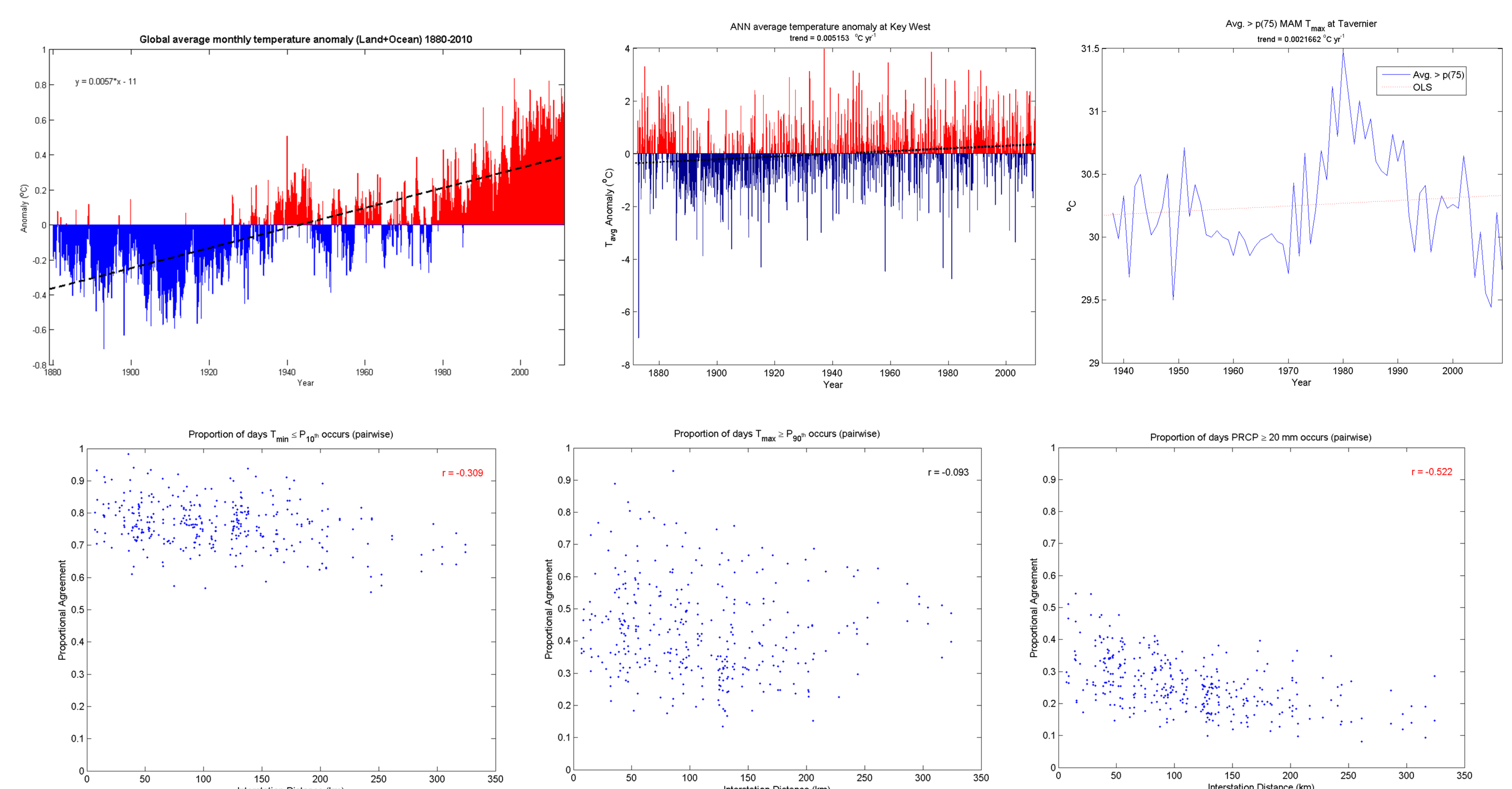
Locations (green arrows) of in situ monitoring stations in the Papahanaumokuakea MNM as of 2011.

Background maps from Google Earth

Individually, a given variable provides only limited information about climate-ecosystem processes, and may contain significant issues that limit its utility. But when examined in a multivariate context, the limitations can be overcome and reveal important connections. In the top left image, IMPACT promotes a paradigm shift from (L) a bivariate input-response scenario to (R) a holistic systems approach that seeks to incorporate forcings and feedbacks from each system as well as external inputs to more accurately quantify climatological effects on ecosystems. In the bottom left image, we attempt to show a representative variety of potential data that can be brought to bear on these analyses. On the right, the three images show how different data have their respective limitations. 50-km satellite SST (R top) provides spatially continuous coverage, but masks much of the near shore zone of interest. *In situ* stations (R middle) provide valuable information for individual locations within the study area, but little knowledge of spatial representativeness. This can vary greatly from one site to another (R bottom) - the Papahanaumokuakea Marine National Monument (white polygon) contains only a few *in situ* sites.

A LOOK AT EXTREMES

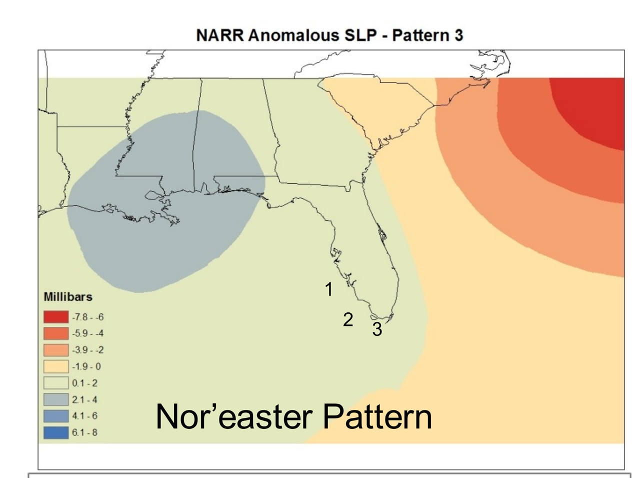
The IMPACT pilot region. We are developing products and tools for IMPACT over South Florida. The region contains a number of Federal and State ecological protected areas, as well as numerous monitoring stations (climate, oceanographic, biological). The Florida Keys National Marine Sanctuary (FKNMS) has been heavily monitored and studied for over 20 years, making it an ideal proving ground. The white boundary represents the FKNMS, and the green rain cloud icons are the stations represented in the graphics below.

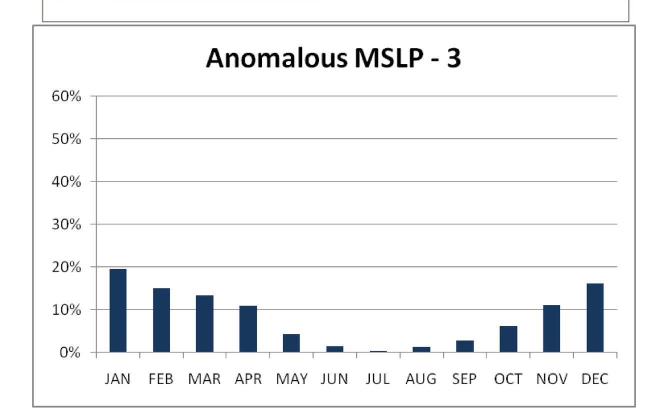


Looking beyond averages: This analysis seeks to examine the spatial and temporal behavior of climate extremes over the pilot area (South Florida). Some ecological impacts are not uniform across the region, and so cannot be adequately explained by regional or global average climate behavior (e.g., top left). It is clear that even local averages (top center) which contribute to the global average, contain far more variability that may account for local impacts not explainable by coarser aggregations. Beyond sample means are statistics associated with the distribution tails. The top right shows behavior of the average of the upper quartile of daily maximum temperatures. Note the rapid and significant decrease since 1980 (a behavior that corresponds well with general decline in ecosystem health in the region). The bottom three figures examine the regional coherence of extreme temperatures and precipitation. Cold days (bottom left) have the greatest coherence and moderate distance decay, while maximum temperatures do not. Precipitation has strong distance decay, but very low interstation correspondence at any distance. For this reason, use of regional averages is not recommended.

Synoptic typing

Study by Cameron Lee and Scott Sheridan, Kent State U.





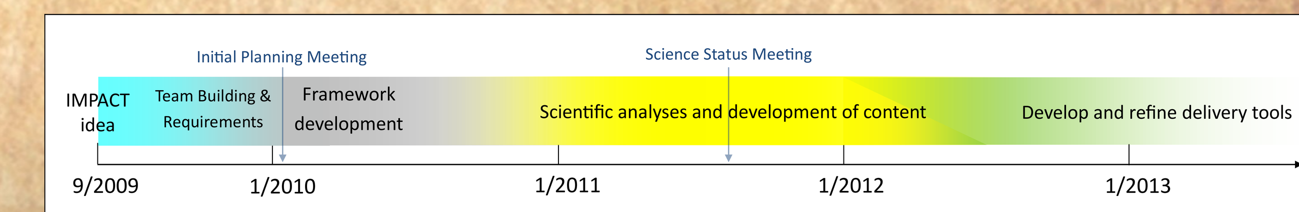
Comparison between daily NARR SLP data and SeaWiFS CHL data (1997-2009)

1. Central FL Shelf
2. So. FL Shelf
3. FL Keys

Relative Ratio of Summed 0-5 day lag CHL levels (1997-2009)

	Keys	S. FL Shelf	C. FL Shelf
JAN	1.04	1.06	1.08
FEB	1.11	1.15	1.19
MAR	1.03	1.03	1.40
APR	1.03	1.02	1.18
MAY	1.01	1.08	1.28
JUN	0.72	0.49	0.50
JUL	1.20	1.09	1.43
AUG	0.98	0.97	1.02
SEP	0.97	0.82	0.93
OCT	1.01	0.97	1.00
NOV	1.00	0.99	0.97
DEC	1.02	1.07	1.13
TOTAL	1.18	1.11	1.18

Preliminary analysis connecting dominant EOF modes of sea level pressure (SLP, from the North American Regional Reanalysis) over the region with the ratio of the summed 5-day (0-5 days after the pressure mode) to average monthly Chlorophyll (CHL) concentration (from SeaWiFS). This figure examines Chlorophyll behavior relative to the 3rd anomalous SLP mode (Nor'easter pattern). In the table, no color means no significant correlation, shades of red indicate significance of elevated concentration ratios, and blues indicate significant decreased concentration ratios. The bar graph above shows how often this mode appears in each month, and the top graphic shows how the Nor'easter SLP anomaly is manifest over the region. For example, this SLP pattern is most common in winter months and, especially during January and February, significantly elevated CHL ratios tend to occur within the week after the appearance of the SLP mode. Manuscripts describing this work are being prepared by Cameron Lee [cclee@kent.edu] and Scott Sheridan [ssherid1@kent.edu] in the Dept. of Geography at Kent State University.



IMPACT Timeline

NOAA's NATIONAL CLIMATIC DATA CENTER – ASHEVILLE, NORTH CAROLINA

http://www.ncdc.noaa.gov • http://climate.gov

Protecting the past… Revealing the future

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